# Modern Biology
## Computerized Laboratories

## *Genetics*

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MODERN BIOLOGY
Computerized Laboratories

# GENETICS

Teacher's Manual

Holt, Rinehart and Winston

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# MODERN BIOLOGY
## Computerized Laboratories

## Genetics
## Teacher's Manual

HOLT, RINEHART AND WINSTON

Developmental Assistance by Prentice Associates Incorporated, 4 Maple Street, Quincy, MA 02130
Program designers: Laurie Beckelman, Lloyd R. Prentice
Content consultant: Kathleen Ebert-Zawasky, Biology Department, Wheaton College, Norton, MA
Programmer: Fred Haer
Illustrator: Daniel Mydlack

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# Section 1

## *Introduction*

The *MODERN BIOLOGY* software series combines computer simulations of biological experiments with selected tutorials that enrich and expand students' understanding of concepts learned in the *Modern Biology* textbook. The *Genetics* program presents a group of six experiments designed to foster progressively deeper insight into the process of genetics. These simulations replicate as closely as possible the logic of actual laboratory experiments. They lead students to apply the scientific method: to observe, question, experiment, record, analyze, and interpret results. In addition, highly graphic, interactive tutorials support the simulations. The tutorials provide motivating content review.

Your *Modern Biology: Genetics* package includes:

- Two double-sided program disks
- One Teacher's Guide with 13 reproducible Laboratory Worksheet masters

To use this program in your classroom you will need:

- An Apple II+, IIe or IIc computer
- A video monitor or TV (color is preferable but not mandatory)

The rest of this Teacher's Guide explains how to use the *Modern Biology* software, describes the contents of the *Genetics* disks, and provides strategies for using *Modern Biology* software in the classroom.

# Section 2

## *Making a Backup*

It is always to your benefit to make a copy of your important disks in case of accidental loss or damage. **Make copies of the *Modern Biology* Disks for every day use and store the original disks for safekeeping.** Use either of the following copy methods.

> Note
>
> Before copying your software, place a write-protect tab (the small adhesive stickers are included with the purchase of blank diskettes) over the squared cutout on the original *Modern Biology* Disk.

**Copying Disks with a DOS 3.3 System Master**

You need two single-sided blank disks to copy each original disk. Label one disk Side 1 and the other disk Side 2.

1. Turn off the computer. Insert the DOS 3.3 System Master disk in Drive 1. Turn on the computer.
2. Press the CAPS LOCK key in the down position.
3. When the red "In Use" light on the disk goes out and you see a blinking cursor on the screen, type RUN COPYA. Press RETURN.
4. When the red "In Use" light on the disk goes out, remove the DOS 3.3

System Master disk.

5. Insert the original *Modern Biology* Disk in Drive 1 (with Side 1 facing up) and the blank disk in Drive 2 (with Side 1 facing up). Be sure there is no write-protect tab on the blank disk. Press RETURN.
6. You are then prompted for the original slot and drive numbers. Enter **6** as the slot number and **1** as the drive number. Press RETURN after you enter both numbers. Next you are prompted for the duplicate slot and drive numbers. Enter **6** as the slot number and **2** as the drive number. Press RETURN after you enter both numbers.
7. The copy process then begins. When it is complete, the question **Do you wish to make another copy?** appears on the screen. Enter **Y** in response to the question. Press RETURN. Remove both disks.
8. Insert the original *Modern Biology* Disk (with Side 2 facing up) in Drive 1 and the target disk (with Side 2 facing up) in Drive 2.
9. Follow step 6. Enter **Y** in response to **Do you wish to make another copy?** Press RETURN. Repeat steps 5 through 9. When you are finished copying disks, enter **N** in response to **Do you wish to make another copy?** Press RETURN.

### Copying Disks with a ProDOS Master

You need two single-sided blank disks to copy the original disk. Label one disk Side 1 and the other disk Side 2.

1. Turn off the computer. Insert the ProDOS Master disk in Drive 1. Turn on the computer. The ProDOS User's Disk Main Menu appears.
2. Press **F** to select the **ProDOS FILER (UTILITIES)** option. The Filer Menu then appears.
3. Press **V** to select the **VOLUME COMMANDS** option. The Volume Commands Menu then appears.
4. Press **C** to select the **COPY A VOLUME** option. The Copy A Volume Menu then appears.
5. Remove the ProDOS Master disk.
6. You are then prompted for the slot and drive numbers. Enter **6** as the source slot number and **1** as the source drive number. The cursor automatically moves to the next line on the screen. Enter **6** as the target slot number and **2** as the target drive number. The message, **INSERT DISKS AND PRESS <RET>,** then appears at the bottom of the screen.
7. Insert the original *Modern Biology* Disk in Drive 1 (with Side 1 facing up) and the blank target disk in Drive 2 (with Side 1 facing up). Be sure there is no write-protect tab on the blank disk. Press RETURN.
8. Enter the name you want to give the target volume (no more than 15 characters) then press RETURN.
   If the target disk is not blank, you are asked to confirm that you want to destroy the information that is saved on the disk. Enter **Y** to continue copying.
   When the message **COPY COMPLETE** appears near the bottom of the screen, press RETURN and remove both disks.
9. Repeat step 6.
10. Insert the original disk (with Side 2 facing up) in Drive 1 and the target disk (with Side 2 facing up) in Drive 2.
11. Repeat step 8. Repeat steps 7 through 11 to copy the second *Genetics* disk. When you are finished, turn off the computer.

# Section 3

## *Loading Modern Biology: Genetics*

To load your *Modern Biology* software:

1. Hold the disk by the label, Side 1 up, and insert it into the disk drive. Close the disk drive door. If you have two disk drives, use Drive 1.
2. Turn on the computer and the monitor or television set.
3. You will hear whirring noises as the program loads. The title sequence will appear.
4. Follow the on-screen instructions: remove the disk from the drive, reinsert it with Side 2 up, close the disk drive door, and press RETURN.

# Section 4

## *Teaching with Modern Biology: Genetics*

*Modern Biology: Genetics* gives you a powerful set of tools with which to augment your teaching of chapters 8 through 13 of *Modern Biology*. The software has two primary goals:

- To reinforce students' knowledge of both genetics and the scientific method through laboratory simulations of experiments that are difficult or impossible to perform in the high school lab.
- To use the graphics, interaction, and animation capabilities of the computer to present concepts that are difficult to teach with conventional methods.

The six units of the program can be used sequentially or independently of one another. Each lab and theory module is carefully structured to require little or no teacher support, and further, to take no more than 20 to 30 minutes to complete.

To benefit most from the *Genetics* software, your students should already be familiar with the following concepts:

- Scientific method
- Characteristics of living things
- The nature of DNA
- Mitosis

*Modern Biology: Genetics* covers the following content:

### DISK 1

#### *1. Review of Meiosis*

**Theory: Review of Meiosis**

This introductory theory module provides a step-by-step animation of meiosis from Interphase I through Telophase II. It covers both spermatogenesis and oogenesis and focuses students' attention on the essential difference between haploid and diploid cells.

#### *2. Mendelian Genetics*

**A. Lab: Predicting Offspring**

Students use the Punnett square to predict phenotypes of the offspring of parents of known genotype. They then carry out a cross to test their prediction. The level 1 lab uses crosses for one trait; level 2, two traits.

Students are lead to discover the phenotypic ratios of Mendelian inheritance. An extended tutorial on how to use a Punnett square is available for students who need it.

**B. Theory: Review of Mendelian Genetics**

The theory module defines genetics, then leads students to discover the way in which offspring inherit nonlinked dominant and recessive traits from their parents. The tutorial reviews concepts including parental and filial generations, phenotype, genotype, homozygous, heterozygous, dominant and recessive alleles..

### *3. Your Test Organism: The Fruit Fly*

**A. Lab: Determining Parental Genotypes**

Students determine parental genotypes based on an examination of phenotypic frequencies in a population of randomly generated offspring. The level 1 lab uses one trait; the level 2 lab, two. Students can use a Punnett square to help them with their analyses if desired.

**B. Theory: Your Test Organism: The Fruit Fly**

This tutorial introduces *Drosophila melanogaster* sp., explains why it is a preferred organism for studying genetics, and uses a zoom sequence to familiarize students with the fruit fly's anatomy.

## DISK 2

### *1. Other Patterns of Inheritance*

**A. Lab: Determining Patterns of Inheritance**

This lab challenges students to determine the pattern underlying the inheritance of different traits. The level 1 lab uses fruit flies; the level 2 lab, humans. Students select a trait and two parents, then carry out a cross and determine the pattern of inheritance based on phenotypic frequencies in the offspring. Students are encouraged to carry out more than one cross when necessary to make a sound determination. The simulation provides examples of simple Mendelian inheritance, sex-linkage, and incomplete dominance. The use of human traits in the level 2 lab introduces the concept of applied genetics.

**B. Theory: Other Patterns of Inheritance**

The tutorial introduces non-Mendelian inheritance patterns. It specifically reviews sex-linkage, incomplete dominance, and codominance.

### *2. Crossing Over and Gene Linkage*

**A. Lab: Gene Linkage**

Students conduct test crosses, then interpret recombination data in order to determine whether or not two genes are linked. They must determine the number of map units separating linked traits.

**B. Theory: Review of Crossing Over and Linkage**

The tutorial uses simulated crosses and an animation of crossing over to review linkage. It introduces gene maps and helps students understand the importance of mapping chromosomes.

### *3. Hardy-Weinberg Equilibrium*

**Theory: Hardy-Weinberg Equilibrium**

This summary tutorial expands students' understanding of genetics to the population level. It introduces the Hardy-Weinberg Equilibrium and provides a concrete example of how the equilibrium is altered in nature.

# Section 5

# *Using Modern Biology: Genetics*

## *Special Keys*

*Modern Biology* software uses clear, on-screen prompts throughout to guide the user. There is, however, one special key that does not appear on screen: ESC.

The ESC key will take the user back to the previous menu. The user who presses ESC when in the middle of a tutorial or lab will return to the submenu. Pressing ESC from a submenu will return the user to the main menu. If the user has come to a tutorial from a lab rather than from a menu (this feature is described in greater detail later in this manual, under laboratory help options), ESC will return the user to the lab.

## *The Main Menu*

The Main Menus for *Modern Biology: Genetics* offer the following choices:

DISK 1

1. Review of Meiosis
2. Mendelian Genetics
3. Your Test Organism: The Fruit Fly

DISK 2

1. Other Patterns of Inheritance
2. Crossing Over
3. Hardy-Weinberg Equilibrium

Use the up and down arrow keys to highlight the unit you want, then press RETURN to select. You will use this basic menu selection technique throughout the program.

Once you have selected a unit to study, you will have a choice of going directly to the laboratory simulation or of viewing the tutorial. Following is a description of interactions necessary to use these modules.

## *Laboratory Simulations*

Each laboratory simulation is divided into three major sections: protocol, laboratory, and conclusions. In addition, some of the labs offer experiments at two levels, each with its own protocol, laboratory, and conclusions.

**Protocol:** The Protocol screens introduce the experiment, let you select a hypothesis to test, and provide a review of the procedure for running the experiment. Clear, on-screen prompts guide the student through this part of the simulation. No special instructions are necessary.

**Laboratory:** The lab screens are divided into three parts. A command menu that runs across the top of the screen lets you set up and run an experiment, exit from the experiment, or receive help. Use the ← (left) and → (right) arrow keys to choose an option and RETURN to select. A text area at the bottom part of the screen provides instructions, prompts, and feedback. The central part of the screen contains the lab set-up.

If you select ? (Help) from the command menu, you have three options:

- Commands: tells you how to use the command menu.
- Procedure: reviews the procedure for running the experiment.

- Theory: takes you to the content tutorial. By pressing ESC, you can move from the lab to the tutorial and back again at any time, except while an experiment is actually running or while tutorial questions are being asked. You will always return to where you left off in the lab. To return from the tutorial to the lab, press ESC.
  *The labs for Mendelian Genetics and Your Test Organism: the Fruit Fly offer an additional help option. If you select* Punnett from the help menu, you will receive instructions on how to fill in the computer-generated Punnett squares.

**Conclusions:** Each lab concludes with questions that encourage students to interpret their experimental results and determine whether or not their hypothesis is correct. The program provides immediate feedback to both correct and incorrect responses.

# *Tutorials*

The theory modules are highly graphic and interactive. They use two central approaches in presenting material, one for presenting structures such as the fruit fly; the other for presenting processes such as meiosis. Organisms are presented through a student-controlled "zoom" sequence that moves through increasingly detailed studies of the organism. Processes are presented through student-controlled animation sequences. As the student presses a key, the computer simulates the next step of the process under study. In addition to the zoom and animation routines, the theory modules incorporate interactive questions with immediate feedback to help students integrate the material they are learning. Except where specifically instructed, students use two basic keys to move through the tutorials:

→ moves forward a screen
← moves back one or more screens

Some questions in the tutorials require students to enter a number. In all of these cases, the computer will accept numbers only within a certain range. If the student tries to enter a number out of range (or a character other than a number), the computer will beep. If this happens, press the back arrow key to erase the entry and try again. Most often, the range of acceptable numbers reflects the range of legitimate answers to the question asked. The highest number the computer will ever accept is 10000.

# *Uses in the Classroom*

*Modern Biology: Genetics* is carefully designed to provide maximum flexibility for classroom use. Both the labs and tutorials are appropriate for:

- **Individual Student Work**

The tutorials provide an excellent introduction to or review of concepts underlying the labs. Because students can move both forward and backward through the tutorials (and back and forth from a lab to a tutorial), they can master the material at their own pace. The labs also provide excellent opportunities for self-paced, individualized learning.

- **Cooperative Learning**

The labs can stimulate interesting group work and discussion. Three students working together, for example, could each select a different hypothesis to test, record experimental results, then discuss these results relative to the different hypotheses before answering the laboratory's concluding questions.

- **Whole Class Presentations**

You can use both the labs and the tutorials for classroom demonstrations. The modular presentation of the tutorial material makes it easy to find specific sections that can reinforce your classroom teaching.

## *How to Use the Laboratory Worksheets*

Reproduce enough copies of the Laboratory Worksheets to give one to each student who will use the *Modern Biology* simulations. Hand out the appropriate worksheets before students begin the lab. Have students fill in Part I of the worksheet as they review the Protocol section of the lab. As students run the lab, they should record their results in Part II of the worksheet. If you anticipate that students will run the experiment more than once, provide additional copies of the worksheets so that they can record data for each experiment.

Encourage students to fill in Part III of the worksheet before they answer the concluding questions in the laboratory simulation. In this way, they can double-check their own reasoning against the simulation's concluding questions.

You can use Part IV of the worksheets as enrichments or as quizzes to conclude your teaching unit on the process of genetics.

# Section 6

# *Laboratory Enrichments with Worksheets*

## *Review of Meiosis*

## *Theory: Review of Meiosis*

### *Objectives:*

- To define meiosis and gametes.
- To illustrate the difference between haploid and diploid cells.
- To provide a visual, animated review of meiosis.
- To show the similarities and differences between spermatogenesis and oogenesis.
- To reinforce the fact that offspring inherit half of the genes from one parent and half from the other.

### *Teaching ideas:*

Introduce meiosis through a comparison with mitosis. Students who understand the similarities and differences between the two processes are most likely to understand the reductional nature of meiosis. Slides of seminiferous tubules or scanning electron micrographs of sperm can provide valuable visual support for discussion. Have students make charts of the number of chromosomes in different organisms' cells in their haploid and diploid states.

### *Enrichments:*

The meiosis/fertilization cycle occurs in all organisms that reproduce sexually. However, the time between the two events differs greatly. Have students research the life cycle of one member of each of the four eukaryotic kingdoms. They might illustrate the life cycle of the representative organisms with special emphasis on the relationship between meiosis and fertilization.

## *References:*

F. J. Ayala and J. A. Kiger, Jr. *Modern Genetics, Second Edition.* Reading, MA: The Benjamin Cummings Publishing Co., Inc., 1984: 12-24.

L. C. Junqueira and J. Carneiro. *Basic Histology, Third Edition.* Los Altos, CA: Lange Medical Publications, 1980: 444-454.

R. G. Kessel and R. H. Kardon. *Tissues and Organs: A Text-Atlas of Scanning Electron Microscopy.* San Francisco: W. H. Freeman and Company, 1979: 262-268.

# *Mendelian Genetics*

## *Theory: Review of Mendelian Genetics*

### *Objectives:*

- To introduce the concept of heredity.
- To describe genes and alleles.
- To show how genes are passed from parents to offspring.
- To define dominant, recessive, phenotype, genotype, heterozygous, and homozygous.
- To introduce genetic notation.
- To introduce the concept of independent assortment.

### *Teaching ideas:*

Mendel's discovery of the integrity of the gene and its preservation through generations is the core of the lesson, but the method he used to reach his conclusions is almost as important as his findings. Mendel's experimental design, the organization of his data, and the logic leading to his principles provide a model of scientific reasoning. Discuss these with students.

Have students observe examples of simple Mendelian inheritance in their classmates. Such traits as widow's peak, tongue rolling, and PTC tasting follow Mendelian inheritance patterns. If you have access to a good scientific library, you might find a copy of *Mendelian Inheritance in Man: Catalogs of Autosomal Dominant, Autosomal Recessive and X-Linked Phenotypes* to share with your students.

### *Enrichments:*

Mendel's work has been preserved and reprinted. Advanced students will benefit from reading some of this great scientist's original work. Students can prepare brief summaries of the work and translations of some of Mendel's terminology into modern genetics lingo.

### *References:*

F. J. Ayala and J. A. Kiger, Jr. *Modern Genetics, 2nd Edition.* Reading, MA: The Benjamin/Cummings Publishing Co., Inc., 1984: 28-44

V. A. McKusick, Editor. *Mendelian Inheritance in Man: Catalogs of Autosomal Dominant, Autosomal Recessive and X-Linked Phenotypes.* Baltimore: The Johns Hopkins University Press, 1983.

G. Mendel. "Experiments in Plant Hybridization," in *Classic Papers in Genetics*, J. A. Peters, Ed. Englewood Cliffs, NJ: Prentice-Hall, 1959: 1-20.

R. H. Tamarin. *Principles of Genetics*. Boston: Willard Grant Press, 1982: 3-14.

# *Lab: Predicting Offspring, Levels 1 and 2*

## *Objectives:*

- To understand and use the Punnett square as a tool for predicting the phenotypic frequencies of offspring of parents of known genotypes.

## *Teaching ideas:*

Before using this simulation, make sure that students are familiar with the following concepts and terms: meiosis, gametes, fertilization, allele.

Introduce students to the Punnett square. Explain that the Punnett square representations in the simulation show all gametes and all possible offspring. Have students practice Punnett squares before and after they do the simulation.

Discuss the concepts of prediction and mathematical models. Use a coin toss to simulate the process of predicting offspring. Use a Punnett square with the "gametes" for heads and tails to predict the ideal results, then have students toss the coins. Discuss the need for standardized evaluation of data, for example, "goodness of fit" as determined by the chi square test.

## *Enrichments:*

1. Students who have mastered the use of Punnett squares for predicting offspring with one or two traits can set up Punnett squares for three traits. Help students recognize that the number of gametes is always $2^n$, with $n$ representing the number of traits being crossed.
2. Students experienced in using electronic spreadsheets can create computerized Punnett squares. After they have filled in the gametes, they can use the copy function to fill in offspring.

## *References;*

F. J. Ayala and J. A. Kiger, Jr. *Modern Genetics, 2nd Edition*. Reading, MA: The Benjamin/Cummings Publishing Co., Inc., 1984: A1-1—A1-6.

R. H. Tamarin. *Principles of Genetics*. Boston: Willard Grant Press, 1982: 63-77.

Name _____ Date _____

# LABORATORY WORKSHEET

## *Lab: Predicting Offspring—Level 1 or 2*

I. What is the purpose of this experiment? _____

_____

What are the genotypes of the parents? _____

_____

What do you predict will happen? _____

II. Record your data in the table below.

| Phenotype | Number of Offspring |
|---|---|

What is the phenotypic ratio? _____

What is your hypothesis? _____

_____

III. Do your data support your hypothesis? _____

_____

What is your conclusion? _____

_____

HRW material copyrighted under notice appearing earlier in this work.

# *Lab: Predicting Offspring—Levels 1 and 2*

IV. Instructions: Answer the following questions on a separate sheet.

1. Why must you represent every possible gamete for the male and the female in order to predict offspring?

2. What does each block inside the Punnett square represent?

3. If a trait (e.g., seed texture) is controlled by two alleles, why do you identify only one allele for each gamete?

4. Which part of the Punnett square shows that Mendel's Law of Segregation is operating?

5. Why is meiosis sometimes called *reduction division?*

6. Which parts of the Punnett square represent cells that are diploid?

7. Which parts of the Punnett square represent cells that are haploid?

8. A student crossed parents with the genotypes Tt and Tt. Of the offspring, 71 showed the dominant trait and 29 showed the recessive trait. Do these results support the ratio predicted with a Punnett square?

9. If you are studying two traits of an organism and the organism is hybrid for both (e.g., AaBb), how many kinds of gametes will be formed?

10. Can the Punnett square help you determine the genotypes of parents if you know only the phenotypes of their offspring?

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# Your Test Organism: The Fruit Fly

## Theory: Your Test Organism: The Fruit Fly

### Objectives:

- To introduce the fruit fly as a genetically complex organism that can serve as a model for other animals.
- To support the choice of the fruit fly as an important organism for genetic research.
- To familiarize students with the anatomy of the fruit fly.

### Teaching ideas:

The selection of suitable organisms for study is important to the success of many kinds of research. Discuss various "contestants" for genetics research with your students. Help them see why the fruit fly is a suitable organism.

Students can study the live experimental organism *Drosophila melanogaster* sp. or another species of fruit fly. Students can attract flies with ripe fruit, then catch them in a jar and examine them using a hand lens or dissecting microscope. They can also purchase cultures from a biological supply house. Familiarity with the life cycle and anatomy of the test organism will enrich students' appreciation of the computer simulations.

### Enrichments:

These labs and theory modules deal with traits that can be seen. Advanced students might enjoy exploring the inheritance of traits that are not visible. Inheritance of enzymes in fruit flies is a challenging, enriching topic.

### References:

P. Abramoff and R. G. Thomson. *Laboratory Outlines in Biology—IV*. San Francisco: W. H. Freeman and Co., 1986: 219-227, 523-529.

G. P. Sanders. *Laboratory Manual, Biology: The Science of Life*. Glenview, IL: Scott, Foresman and Company, 1986: 73-86.

## Lab: Determining Parental Genotypes—Level 1

### Objectives:

- To sort offspring by phenotype and extrapolate parental genotypes.
- To become familiar with some of the techniques geneticists use to study inheritance.

### Teaching ideas:

To adequately complete this lab, students must understand how they can deduce parental genotypes from offsprings' phenotypes. A discussion of human familial traits might help students grasp this concept. Identify several dominant human traits, such as widows peak and cleft chin, that are governed by a single gene. Lead students to identify possible parents of offspring with or without these traits. Broaden the discussion to cover the influence of factors such as develop-

ment, environment, and mutation on the expression of genetic traits.

This lab makes certain assumptions about the population of fruit flies and the traits under study. It assumes:

1. that one allele for each trait is dominant, the other recessive.
2. that all offspring produced survived.
3. that each of the 16 offspring on screen represents approximately 20 flies.
4. that each phenotypic group consists of equal numbers of males and females.

Discuss these assumptions with your students. Elicit their opinions on why these assumptions are important and on whether the experiment would be valid if one or more of the assumptions were changed.

## *Enrichments:*

Students can tally the offspring represented in a population of genetic corn seeds and try to deduce the parental genotypes. For example, a 3:1 ratio of wrinkled to smooth kernels should lead students to conclude that the parents were both hybrid for texture. This activity reflects the logic upon which the simulation is based.

## *References:*

P. Abramoff and R. G. Thomson. *Laboratory Outlines in Biology—IV*. San Francisco: W. H. Freeman and Co., 1986: 219-227, 523-529.

D. L. Hartl. *Human Genetics*. New York: Harper & Row Publishers, 1983: 79-91.

Name _____ Date _____

# LABORATORY WORKSHEET

## *Lab: Determining Parental Genotypes—Level 1*

I. What is the purpose of this experiment? _____

_____

What trait have you selected? _____

_____

II. Record your data in the table below.

| Phenotype | Number of Offspring |
|---|---|

What is the phenotypic ratio? _____

What is your hypothesis? _____

_____

III. Do your data support your hypothesis? _____

_____

What is your conclusion? _____

_____

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# *Lab: Determining Parental Genotypes—Level 1*

IV. Instructions: Answer the following questions on a separate sheet.

1. Why must many offspring be produced before you can determine parental genotypes?

2. One of the assumptions upon which this simulation is based is that all of the offspring flies survive. Why is this important?

3. Why are offspring grown in the lab more reliable candidates for this type of experiment than those found in nature?

4. Why should the investigator know about the life cycle of the experimental organisms?

5. If all offspring show the dominant trait, can you conclusively determine the parents' genotypes?

6. If all offspring show the recessive trait, can you conclusively determine the parents' genotypes?

7. If you cannot confidently determine the parental genotypes from the offspring, how can you get more information?

8. In this simulation, the offspring show ideal phenotypic ratios. Will a group of real offspring also show ideal ratios?

9. The rh factor found in human blood is inherited by simple Mendelian genetics. The dominant gene is Rh+. The recessive gene is rh-. Which of the following set of parents could be those of an rh- child?
   a. Rh+rh- X Rh+rh-
   b. Rh+Rh+ X rh-rh-

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# *Lab: Determining Parental Genotypes—Level 2*

## *Objectives:*

- To recognize common phenotypic ratios in a group of offspring.
- To use these phenotypic ratios to determine parental genotypes.
- To become familiar with the practical application of Mendel's Law of Independent Assortment.

## *Teaching ideas:*

Review Mendel's Law of Independent Assortment before beginning this lab. Emphasize that the traits represented in this simulation are governed by genes located on different chromosomes and therefore assort independently. Show slides of gametogenesis, or use the Review of Meiosis module from this disk, to reinforce the connection between chromosomes and genes and to provide a visual reminder that the organism has many distinct chromosomes.

Students can once again sort a population of genetic corn by phenotypic group, this time considering two traits. The phenotypic ratios they derive should suggest parental genotypes.

## *Enrichments:*

1. You can extend your students' understanding of genetics by challenging them to consider how the data from this lab would differ if the genes for the traits were located on the same chromosome.
2. By the time students have completed this lab, they should be able to critique the simulation. Some topics to discuss:
   a. the use of the fruit fly rather than an alternative organism such as humans or corn.
   b. the validity of applying insights gained form studying one organism to another organism.
   c. the limitations of a computer simulation.

## *References:*

P. Abramoff and R. G. Thomson. *Laboratory Outlines in Biology—IV*. San Francisco: W. H. Freeman and Co., 1986: 219-227, 523-529.

R. H. Tamarin. *Principles of Genetics*. Boston: Willard Grant Press, 1983 3-26.

Name _____ Date _____

# LABORATORY WORKSHEET

## *Lab: Determining Parental Genotypes—Level 2*

I. What is the purpose of this experiment? _____

_____

What traits have you selected? _____

_____

II. Record your data in the table below.

| Phenotype | Number of Offspring |
|---|---|

What is the phenotypic ratio? _____

What is your hypothesis? _____

_____

III. Do your data support your hypothesis? _____

_____

What is your conclusion? _____

_____

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IV. Instructions: Answer the following questions on a separate sheet.

1. What is a gene?

2. Explain Mendel's Law of Independent Assortment. Use genes for wing form and eye color as your example.

3. The genes for all of the traits used in this experiment are on different chromosomes. Would the offspring show the same phenotypes if the genes were on the same chromosome?

4. What type of cross yields a 9:3:3:1 phenotypic ratio?

5. Here are the results of an actual cross:

| PHENOTYPE | NUMBER OF OFFSPRING |
|---|---|
| Brown body/ normal wings | 58 |
| Brown body/ dumpy wings | 18 |
| Ebony body/ normal wings | 17 |
| Ebony body/ dumpy wings | 7 |

a. What ratio do these data most closely represent?

b. How many flies have normal wings?

c. How many flies have dumpy wings?

d. What is the ratio of normal to dumpy wings?

e. What is the ratio of brown to ebony body color?

6. What is the relationship between a 9:3:3:1 ratio and a 3:1 ratio?

7. Here are the results of a simulated cross:

| PHENOTYPE | NUMBER OF OFFSPRING |
|---|---|
| Sepia Eyes/ normal wings | 160 |
| Red eyes/ dumpy wings | 160 |
| Sepia eyes/ normal wings | 160 |
| Red eyes/ dumpy wings | 160 |

a. What ratio do these data most closely represent?

b. What must the genotypes of the parents be?

c. What is the ratio of normal wings to dumpy wings?

d. What is the ratio of sepia eyes to red eyes?

e. What type of cross does this represent?



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# DISK 2

## *Other Patterns of Inheritance*

## *Theory: Other Patterns of Inheritance*

### *Objectives:*

- To distinguish autosomes and sex chromosomes.
- To define sex linkage, codominance, and incomplete dominance.
- To distinguish sex linkage from simple Mendelian inheritance.
- To distinguish codominance from Mendel's concept of dominance.
- To explain the inheritance of color blindness and snapdragon pigmentation as examples of non-Mendelian patterns of inheritance.

### *Teaching ideas:*

Precede this lesson with a review of Mendel's laws. Remind students that Mendel's work dealt with genes located on different chromosomes, for which one allele dominated over the other. Then challenge your students as a group to list as many traits as they can. Point out that some of these traits cannot be explained by Mendelian theory. Height and skin color, for example, show many intermediate expressions. Prompt your students to formulate hypotheses about why this is so. Two or three good hypotheses should emerge (e.g., that more than two genes are involved, that environment may affect genetic expression, or that dominance may be incomplete). Continue the discussion until students generate some ideas about how these hypotheses can be tested.

### *Enrichments:*

Encourage advanced students to explore such topics as the role of environment in genetic expression, epistasis and polygenic inheritance, expressivity and penetrance.

### *References:*

D. L. Hartl. *Human Genetics*. New York: Harper & Row Publishers, 1983: 125-138.

R. H. Tamarin. *Principles of Genetics*. Boston: Willard Grant Press, 1982: 14-30.

# *Lab: Other Patterns of Inheritance*

## *Objectives:*

- To analyze genetic data in order to determine the pattern of inheritance.
- To contrast Mendelian patterns of inheritance with other patterns
- To recognize sex-linkage and codominance in a group of offspring.

## *Teaching ideas:*

Before they can understand other patterns of inheritance, students must have a good foundation in Mendelian genetics. They should be fluent with the genotypic and phenotypic ratios Mendelian genetics predicts. Have students predict what the phenotypic frequencies of the flies would be if Mendelian principles were operating. When students run the simulation, have them contrast their data with these predictions.

Occasionally remind students that Mendelian genetics and the other patterns represented here are restricted to organisms that reproduce sexually. Other organisms, such as bacteria, reproduce in a different way and have very different patterns of inheritance.

## *Enrichments:*

Students who have grasped the patterns of inheritance covered in this lab can be challenged to investigate such other patterns as polygenic and cytoplasmic inheritance. Cytoplasmic inheritance is particularly interesting since geneticists have only recently recognized its importance in humans.

## *References:*

F. J. Ayala and J. A. Kiger, Jr. *Modern Genetics, Second Edition*. Reading, MA: Benjamin/Cummings Publishing Co., 1984: 35-39, 61-77.

R. H. Tamarin. *Principles of Genetics*. Boston: Willard Grant Press, 1982: 565-590.

Name _____ Date _____

# LABORATORY WORKSHEET

## *Lab: Other Patterns of Inheritance—Level 1*

I. What is the purpose of this experiment? _____

_____

What traits have you selected? _____

_____

What do you predict will happen? _____

_____

II. Record your data in the table below.

| Phenotype | Number of Offspring |
|---|---|

What is the phenotypic ratio? _____

What is your hypothesis? _____

_____

III. Do your data support your hypothesis? _____

_____

What is your conclusion? _____

_____

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IV. Instructions: Answer the following questions on a separate sheet.

1. Do all genes show dominance or recessiveness?

2. List three patterns of inheritance other than Mendelian inheritance.

3. What is the phenotypic difference between a heterozygous individual whose genes show dominance and one whose genes show codominance?

4. What is a reciprocal cross? When might one be necessary to determine the correct pattern of inheritance?

5. What is the difference between the X and the Y chromosomes in the fruit fly and in humans?

6. Why are some of a female's recessive traits more likely to be expressed in her sons than in her daughters?

7. The offspring of two blue-gray Andalusian fowl are:
   25 percent black
   50 percent blue-gray
   25 percent white
   What pattern of inheritance do these data suggest?

8. This simulation assumes that each on-screen offspring represent 20 flies. Why is this important?

9. A student conducting a genetics experiment noticed a trait in one of the offspring that was not represented in either the parents or the grandparents. What could explain this new trait?

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# *Lab: Other Patterns of Inheritance—Level 2*

## *Objectives:*

- To recognize patterns of inheritance in humans.
- To understand the implications of these patterns.

## *Teaching ideas:*

In this lab, students will determine the pattern of inheritance of human traits including such genetic diseases as Tay Sachs and sickle cell disease. Discuss with students that in enzymatic diseases such as Tay Sachs, heterozygotes do not express the disease; Tay Sachs is dominant on the phenotypic level. However, the disease is codominant on the enzymatic level because heterozygotes have only half of the normal level of enzymatic activity. This allows for genetic screening of possible carriers. This lab provides an excellent context for discussing the hotly debated fields of genetic screening and genetic engineering. You might consider organizing a class debate on these topics. Who should be screened? Should a carrier of a fatal genetic disease be prevented from having children? If we screen for fatal genetic diseases, how about for those that are not necessarily fatal, such as hemophilia? Should geneticists be allowed to engineer "improved" human genes? Do they know enough about human genetics to do so today?

## *Enrichments:*

1. Challenge students with this thought: The gene for sickle cell disease has obvious deleterious effects. Why has it not been eliminated through natural selection? Discuss the link between resistance to malaria and sickle cell disease as an interesting example of natural selection and heterozygote advantage.
2. Here's another challenge for your students: If two albinos marry, they can have children with normal pigmentation. Since albinism is a recessive trait, how is this possible? The answer to this question reveals the complexity of human genetics. Two enzymes are necessary for normal pigmentation. If one parent is missing one of the enzymes, and the other is missing the other, they could each theoretically contribute a normal gene to their children.

## *References:*

D. L. Hartl. *Human Genetics.* New York: Harper & Row, Publishers, 1983: 93-106, 125-138.

R. H. Tamarin. *Principles of Genetics.* Boston: Willard Grant Press, 1982: 644-651.

Name _____ Date _____

# LABORATORY WORKSHEET

## *Lab: Other Patterns of Inheritance—Level 2*

I. What is the purpose of this experiment? _____

_____

What traits have you selected? _____

_____

What do you predict will happen? _____

_____

II. Record your data in the table below.

| Phenotype | Number of Offspring |
|---|---|

What is the phenotypic ratio? _____

What is your hypothesis? _____

_____

III. Do your data support your hypothesis? _____

_____

What is your conclusion? _____

_____

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# *Lab: Other Patterns of Inheritance—Level 2*

IV. Instructions: Answer the following questions on a separate sheet.

1. Human genetics is harder to study than that of experimental organisms such as the fruit fly. Why?

2. What is a pedigree and why is it useful in studying human genetics?

3. Some traits such as height, weight, and intelligence are not as predictable as others. Why?

4. This lab assumes equal numbers of male and female offspring. This is not always true in families. Why?

5. Some people are carriers of genetic disease. Define a carrier. Would a carrier be hetero- or homozygous for the trait?

6. A woman has a brother with a sex-linked genetic disease. What is the probability that she is a carrier?

7. There are three alleles for blood type: A, B and O. A woman with type AB blood marries a man with type A blood. They have three children. One has type AB blood, one type A, and the third type B.
   a. Which offspring genotype(s) show(s) codominance?
   b. Which offspring genotype(s) show(s) dominance?

8. What pattern of inheritance does the famous Royal Hemophilia show?

9. Tay-Sachs disease shows dominance on the phenotypic level and incomplete dominance on the biochemical level. Explain.

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# Crossing Over and Gene Linkage

## Theory: Review of Crossing Over

### Objectives:

- To relate deviations from Mendel's predictions to crossing over.
- To distinguish between closely linked genes and genes that are far apart.
- To define gene map, recombinant, and map unit.
- To determine the order of three linked genes from the results of a three-point cross.

### Teaching ideas:

Make the abstract concepts introduced in this module more concrete by having students create models of chromosomes and gene maps. Use pipe cleaners for the chromosomes and beads for the genes. Simulate meiosis using the pipe cleaner models. Remind students that meiosis is a reduction division that produces haploid gametes. With the addition fo a pair of scissors to your "chromosome kit," you can demonstrate crossing over in addition to gene linkage.

### Enrichments:

Advanced students can research the gene maps that are available for *Drosophila*. They can compare these with gene maps of *E. coli* and humans.

### References:

F. J. Ayala and J. A. Kiger, Jr. *Modern Genetics, Second Edition.* Reading, MA: The Benjamin Cummings Publishing Co., Inc., 1984: 123-134.

E. A. Goodrick. *Principles of Biology II Laboratory Manual, Second Edition.* Lexington, MA: Ginn Press, 1985: 107-108.

## Lab: Linkage

### Objectives:

- To analyze recombination data in order to distinguish genes that are linked from those that are not.

### Teaching ideas:

Before beginning this lab, you may want to help students appreciate the difficulty of mapping human chromosomes vs mapping fruit fly chromosomes. The techniques are useful for organisms such as the fruit fly, but not useful in mapping the human genome.

## *Enrichments:*

Advanced students might explore other methods by which chromosomes can be mapped. Such new techniques as somatic-cell hybridization and chromosome banding are proving useful in constructing human gene maps.

## *References:*

F. J. Ayala and J. A. Kiger, Jr. *Modern Genetics, Second Edition*. Reading, MA: The Benjamin Cummings Publishing Co., Inc., 1984: 121-134.

R. H. Tamarin. *Principles of Genetics*. Boston: Willard Grant Press, 1982: 149-162.

Name Date

# LABORATORY WORKSHEET

## *Lab: Linkage*

I. What is the purpose of this experiment?

What is your hypothesis?

What traits have you selected?

What do you predict will happen?

II. Record your data in the table below.

| Phenotype | Number of Offspring |
|---|---|

III. Do your data support your hypothesis?

What is your conclusion?

If these genes are linked, how many map units apart are they?

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# *Lab: Linkage*

IV. Instructions: Answer the following questions on a separate sheet.

1. Clearly define the following terms:
   a. parental

   b. recombinant

2. Why must one parent used for the crosses in this lab always be heterozygous for the traits?

3. Why must the other parent always be recessive for both traits?

4. Will linked genes usually go to the same gamete or different gametes during meiosis?

5. If the genes for the recessive traits pink eyes and striped body are closely linked on an autosomal chromosome, what is the expected phenotypic frequency of a cross between these mates:
   Female: PpSs Male: ppss

6. What will the offspring of the above cross be if crossing over takes place?

7. Would the expected phenotypic ratios be different if the male were red eyed and brown bodied (heterozygous dominant) and the female were pink eyed and striped?

8. What is a map unit?

9. Mendel collected data on seven traits in pea plants. Could his data be used for mapping the chromosomes of pea plants?

10. Assume that the genes for yellow, white, and vermilion eyes in fruit flies are all on the same chromosome. Yellow and white are one map unit apart. White and vermilion are 30 map units apart. Which genes will cross over most often?
    a. yellow and white

    b. white and vermilion

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# Hardy-Weinberg Equilibrium

## *Theory: Hardy-Weinberg Equilibrium*

### *Objectives:*

- To define population and population genetics.
- To introduce the Hardy-Weinberg equilibrium and its assumptions.
- To provide a concrete example of violations of the Hardy-Weinberg equilibrium.
- To demonstrate the mathematical basis of the Hardy-Weinberg equilibrium.
- To elicit students' recognition that the equilibrium is more often altered than upheld.

### *Teaching ideas:*

Demonstrate the mathematical basis of the Hardy-Weinberg equilibrium with a classroom tally of students who are dominant and recessive for the ability to taste phenylthiocarbamide (PTC): The frequency of tasters (p) plus the frequency of nontasters (q) will equal 100 percent, or 1.0.

Write the five factors that influence gene frequency and their state at equilibrium on the board. Your chart might look like this:

| FACTOR | AT EQUILIBRIUM |
|---|---|
| Migration | None |
| Natural Selection | Not operating |
| Mutation | None |
| Population | Large |
| Random mating | Yes |

Have students select an animal, such as the cheetah, and speculate on ways in which the Hardy-Weinberg factors could be altered to affect the frequency of genes in the population.

### *Enrichments:*

The history of the peppered moth and air pollution in England is a well-documented case of natural selection in operation. Have students research the case of the peppered moth and relate their findings to the Hardy-Weinberg equilibrium. Other, similar research topics include:

- Why are the mammals of Australia so different from the mammals of other continents?
- What is believed to be the origin of the Galapogos tortoise?

### *References:*

E. O. Dodson and P. Dodson. *Evolution: Process and Product.* Boston: Prindle, Weber and Schmidt Publishers, 1985: 595.

E. A. Godrick. *Principles of Biology I Laboratory Manual, Second Edition.* Lexington, MA: Ginn Press, 1985: 65-71.

G. P. Sanders. *Laboratory Manual, Biology: The Science of Life.* Glenview, IL: Scott, Foresman and Company, 1986: 93-99.

# Section 7

## *Glossary*

**allele:** one of a set of genes that control a particular trait.

**autosome:** any chromosome other than the sex chromosomes.

**anaphase I:** the phase of meiosis I during which homologous chromosomes separate and migrate to opposite poles.

**anaphase II:** the phase of meiosis II during which single chromatids migrate to opposite poles.

**centrioles:** a pair of organelles that migrate to the poles of the cell early in mitosis and meiosis. Centrioles are the center around which spindle fibers form.

**centromere:** a point on a chromosome where chromatids are held together before separating.

**chromatid:** one of two identical strands of a chromosome; they result when DNA replicates during meiosis, prior to cell division.

**chromosome:** a threadlike structure in the cell nucleus that is composed of DNA and proteins.

**codominance:** condition in which two different alleles for a trait are both expressed so that the heterozygote has a different phenotype from either homozygote.

**crossing over:** the exchange of chromatid segments between homologous chromosomes. Crossing over occurs during the prophase I stage of meiosis.

**diploid:** having two sets of homologous chromosomes; in animals, all cells except gametes are diploid.

**dominance:** condition when one allele for a trait masks the expression of another.

**DNA (deoxyribonucleic acid):** the genetic material DNA is a double-helix shaped molecule. Paired nucleotides are the "rungs" of the molecule. They connect alternating sugar and phosphate groups.

***Drosophila melanogaster:*** a tiny fly, commonly called the fruit fly, that is an important experimental organism for geneticists.

**egg:** the female gamete. An egg contains the haploid number of chromosomes in its nucleus and a full complement of organelles in its cytoplasm.

**filial generation:** a generation succeeding the parental generation in a breeding experiment. The first filial ($F_1$) generation is the first generation of offspring; the second filial ($F_2$), the second, etc.

**gamete:** the haploid cells formed during meiosis; sperm and eggs are the gametes in animals.

**gene:** the unit of heredity; one segment of DNA.

**gene map:** a representation of a chromosome that shows the relative positions of that chromosome's genes.

**gene pool:** the sum of all the genes in a breeding population.

**genetic drift:** differences in gene frequencies in one generation compared to another generation or in one isolated group compared to the main population due to random events.

**genetics:** the part of biology that specializes in the study of heredity.

**genotype:** the genetic makeup of an organism.

**haploid:** having one set of chromosomes; gametes are haploid cells.

**Hardy-Weinberg equilibrium:** the theory that gene frequencies in a population remain the same generation after generation if certain conditions, such as random mating and the absence of natural selection are in effect.

**heterozygote:** an organism having two different alleles for a given trait.

**heterozygous:** having two different alleles; hybrid.

**homolog:** one of two chromosomes having identical genetic loci and appearance.

**homozygote:** an organism having two identical alleles for a given trait.

**homozygous:** having two identical alleles.

**incomplete dominance:** condition in which two different alleles for a trait are both expressed so that the heterozygote has a different phenotype from either homozygote.

**independent assortment:** situation in which the alleles of one gene segregate independently of the alleles of other genes during meiosis; Mendel's second law. Independent assortment occurs when genes are on nonhomozygous chromosomes.

**interphase I:** the phase of meiosis prior to cell division

during which DNA is replicated.

**interphase II:** the phase between meiosis I and meiosis II; no new DNA is formed.

**linkage:** situation in which genes are located on the same chromosome and do not show independent assortment.

**locus (pl., loci):** the place on a chromosome at which a gene is located.

**map unit:** the distance between two loci on a chromosome showing a cross-over frequency of one percent.

**meiosis:** a type of cell division in which four haploid cells form from one diploid cell.

**Mendelian genetics:** inheritance patterns discovered by Gregor Mendel; the laws of dominance, segregation, and independent assortment.

**metaphase I:** the brief phase of meiosis II during which homologous chromosomes align at the center of the cell.

**metaphase II:** the brief phase of meiosis II during which doubled chromosomes align at the center of the cell.

**metaphase plate:** the plane at the center of a dividing cell along which the chromosomes align.

**migration:** the exchange of genes between two populations.

**mutation:** a change in a gene that can be inherited.

**natural selection:** process through which better adapted individuals in a population more successfully survive and reproduce, causing changes in the genetic makeup of the population over time.

**nonrandom mating:** situation in which the frequencies of matings between individuals in a population is different from those predicted by chance.

**oogenesis:** the process of meiosis in females during which one diploid cell becomes four haploid cells, an egg and three polar bodies.

**pairing of homologous chromosomes:** the part of prophase I during which homologs attach to one another, forming pairs of doubled chromosomes; also called *synapsis.*

**parental:** an offspring in gene mapping studies that shows the same combination of linked genes as the parent.

**phenotype:** the outward appearance of an organism.

**polar body:** a cell with a haploid nucleus but very little cytoplasm that is produced during oogenesis and dies.

**prophase I:** the first phase of meiosis I, during which chromosomes become visible, homologous chromosomes pair, and crossing over may take place.

**prophase II:** the first phase of meiosis II; no pairing or crossing over takes place.

**population:** a group of organisms belonging to the same species and occupying the same area.

**population genetics:** the branch of genetics that studies the frequencies of alleles in populations and factors that affect those frequencies.

**Punnett square:** a grid geneticists use to predict the results of a particular cross.

**recessive:** an allele that is expressed only when it is homozygous; it is masked by dominant alleles.

**recombinant:** an offspring in gene mapping studies that shows a combination of linked genes different from either parent.

**sex chromosomes:** the two kinds of chromosomes (X and Y) that determine the sex of an offspring.

**sex comb:** a small tuft of black bristles on the front leg of male *Drosophila* sp.

**sex-linked trait:** a trait carried on the X chromosome.

**sperm:** the male gamete; sperm have a haploid nucleus, greatly reduced cytoplasm, and a flagella for mobility.

**spermatogenesis:** the process of meiosis in males through which one diploid cell becomes four haploid sperm.

**spindle fiber:** small fibers that assemble during prophase and that guide chromosomes to the poles later in cell division.

**synapsis:** see *pairing of homologous chromosomes.*

**telophase I:** the last phase of meiosis I, during which the cytoplasm divides into two cells, each of which has the haploid number of doubled chromosomes.

**telophase II:** the last phase of meiosis II, during which the cytoplasm divides into two cells, each of which has the haploid number of doubled chromosomes.

**test cross:** a cross using a parent that is recessive for one or more traits, carried out to determine the genotype of the other parent.

**tetrad:** a group of four chromatids joined at the centromere, present in cells during prophase I.

**three-point test cross:** a cross between a trihybrid and a recessive individual; offspring data are used to construct gene maps.

**trihybrid:** an individual that is heterozygous for three traits, e.g., AaBbCc.

# Section 8

## *Answers to Worksheet Questions*

### *Lab: Predicting Offspring—Levels 1 and 2*

1. You must represent all possible gametes so that you can predict all possible fertilization events. Each egg has an equal chance of being fertilized by each sperm.
2. The genotype of an offspring.
3. The two alleles are separated during meiosis. Each gamete receives only one of the alleles, not both.
4. The parental gametes at the top and along the left side of the square. Only one allele for each trait appears in each of these cells.
5. Meiosis is sometimes called *reduction division* because, during meiosis, the number of chromosomes is reduced by half. The resulting cells—gametes—are haploid.
6. Each block inside of the Punnett square represents a diploid offspring.
7. The parental gametes along the top and the side are haploid.
8. Yes. It is nearly a 3:1 ratio. In nature, the actual results are generally close to but not identical to expected results. Some variation occurs due to chance.
9. Four: AB, Ab, aB, ab.
10. Yes. You can determine the genotypes of the parents if you know the offspring phenotypes (or genotypes). This is only true, however, when many offspring are produced.

### *Lab: Determining Parental Genotypes—Level 1*

1. Because of chance, a small number of offspring may not represent all possible combinations of alleles in the correct proportions to figure out parental genotypes.
2. If some of the offspring die, you may not have a good representation of the offspring those particular parents could produce and so may not be able to determine the correct parental genotypes.
3. Offspring grown in the lab are more reliable because geneticists can contain the entire population and assure that all offspring have equal chances of surviving.
4. Among the many reasons, so that the investigator can:
   a. meet the needs of the organism so that it is healthy and as close to "natural" as possible.
   b. examine the organism for a given trait at the appropriate age. Some genes are expressed in the embryo, some in a larval stage, and others in the adult stage.
5. No. One parent must be homozygous for the dominant trait, but the genotype for the other parent cannot be determined.
6. Yes. The parents can only be homozygous recessive.
7. Carry out additional crosses, such as a test cross, using the offspring. The second filial generation may reveal recessive genes that were present in the parentals, but not expressed in the first filial generation.
8. No. Real data will show ratios that approximate the ideal, but fertilization is subject to the rules of chance.
9. A: Rh+rh– X Rh+rh–

## *Lab: Determining Parental Genotypes—Level 2*

1. A gene is a unit of inheritance. It consists of DNA and is located on a chromosome. Parents pass on traits to their offspring through the genes in their gametes.
2. Mendel's Law of Independent Assortment holds that inheritance of one trait does not influence inheritance of another. The genes for wing form and eye color in fruit flies are located on different chromosomes and therefore separate independently during meiosis. Inheritance of the gene for eye color has no effect on inheritance of the gene for wing form.
3. No. The ratios would not be the same. Genes on the same chromosome are often linked and inherited together.
4. A cross between parents who are both heterozygous for each trait (e.g., AaBb X AaBb). This is called a dihybrid cross.
5. a. 9:3:3:1
   b. 75 (58 + 17)
   c. 25 (18 + 7)
   d. 3:1
   e. 3:1
6. 9:3:3:1 results from a dihybrid cross; 3:1 results from a monohybrid cross. 9:3:3:1 is an expansion of the 3:1 ratio.
7. a. 1:1:1:1
   b. SsDd X ssdd
   c. 1:1
   d. 1:1
   e. test cross

## *Lab: Other Patterns of Inheritance—Level 1*

1. No. Not all genes show dominance or recessiveness. Other patterns are seen. For example, codominance results in an intermediate phenotype.
2. Sex-linkage; codominance; incomplete dominance; autosomal linkage; polygenic inheritance; cytoplasmic inheritance.
3. The heterozygote for the dominant gene will be identical to the homozygote—both will show the dominant trait. The heterozygote for the codominant gene will show an intermediate condition, something between the two homozygous states.
4. A reciprocal cross is one in which the traits shown in the male and female mates in the first cross are reversed for the second cross. For example, if the first cross used a white-eyed male and a red-eyed female, the second would use a red-eyed male and a white-eyed female. Reciprocal crosses are necessary to determine sex-linked traits.
5. The X chromosome is longer and contains many more genes. The Y chromosome determines maleness. It is shorter and has far fewer genes on it.
6. Because they are sex-linked traits, located on the X chromosomes. Sons have only one allele for sex-linked traits since they have only one X chromosome. Therefore, recessive alleles for such traits are always expressed in males.
7. Codominance.
8. Large numbers of offspring are necessary to correctly determine the pattern of inheritance.
9. This information is insufficient to determine the pattern of inheritance. The new trait probably resulted from a mutation, a random change in a gene.

## *Lab: Other Patterns of Inheritance—Level 2*

1. Three reasons are:
   a. Experimental crosses cannot be set up.
   b. The number of offspring in each family is usually too small to provide meaningful information.
   c. Humans have many more genes than fruit flies.
2. A pedigree is a diagram, or family tree, that represents the genetic relationships of people in a family. When geneticists know the traits of people in several generations of the same family, they can sometimes deduce the pattern of inheritance and make predictions about the genotypes of some of the people.
3. Here are two good reasons: These traits are governed by many genes, and, further, they are highly influenced by environmental factors, availability of food, for example.
4. Chance is the reason. Every fertilization event carries a 50/50 chance that a male or a female will result. This is one reason why large numbers of offspring provide better data.
5. A carrier is a heterozygote who does not express the disease but who may pass the gene for the disease on to offspring.
6. Since the disease is carried on the X chromosome, she had a 50 percent chance of inheriting that chromosome.
7. a. AB
   b. The children with A and B blood types are both displaying dominance over the gene for O.
8. It shows sex-linked inheritance. Few females are victims; females are carriers; expression of the allele skips a generation.
9. Two alleles govern expression of Tay-Sachs disease. They control production of enzymes. If an individual is heterozygous, enough properly working enzyme is produced to prevent symptoms of the disease from showing. On the biochemical level, however, some defective enzyme is present, revealing that both alleles are being expressed.

## *Lab: Linkage*

1. a. Parental: an offspring showing the same phenotype for one or more traits as one of the parents.
   b. Recombinant: an offspring showing unlike either parent—it shows a trait from one parent and at least one trait from the other.
2. If a heterozygote is used, its recessive gene will be expressed in the offspring generation. This is only true, of course, if the other parent is a homozygous recessive. The alleles cannot be masked in the offspring by a dominant gene.
3. One parent must be homozygous recessive so that the recessive trait can be seen in the offspring.
4. If genes are linked they will usually go to the same gamete together. If crossing over takes place, however, they can separate.
5. Fifty percent of the offspring will show both recessive traits and 50 percent will show both dominant traits.
6. Small numbers of recombinants, showing one dominant and one recessive trait each, will appear in addition to the parentals.
7. No. Sex would only make a difference if one or the other of these was a sex-linked trait.
8. A map unit is the distance between two genes on a chromosome that cross over one percent of the time.
9. No. The seven traits Mendel studied had their genes on seven different chromosomes. They assort independently and therefore do not provide useful data for constructing gene maps.
10. B: white and vermilion.

# TEACHER'S NOTES

HOLT, RINEHART AND WINSTON
AUSTIN NEW YORK SAN DIEGO CHICAGO TORONTO MONTREAL

O30090

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Protect
Proteger
Protéger
Schützen
保 護

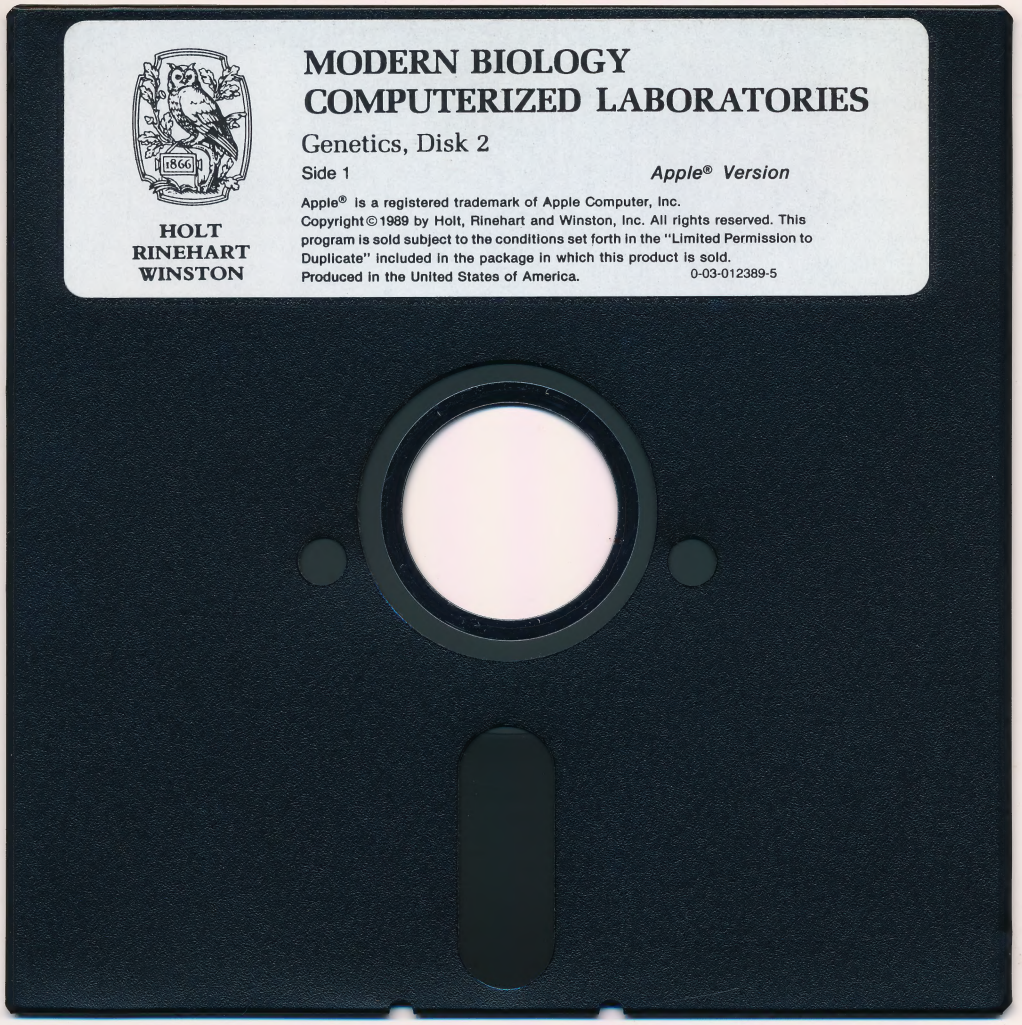
No
No
Non
Nicht
注 意

Insert carefully
Insertar con cuidado
Inserer avec soin
Vorsichtig Einführen
挿入注意

Never touch!
Nunca toque!
Jamais toucher!
Nie Berühren!
絶対禁止

10°C → 52°C
50°F → 125°F

Never
Nunca
Jamais
Nie
絶対禁止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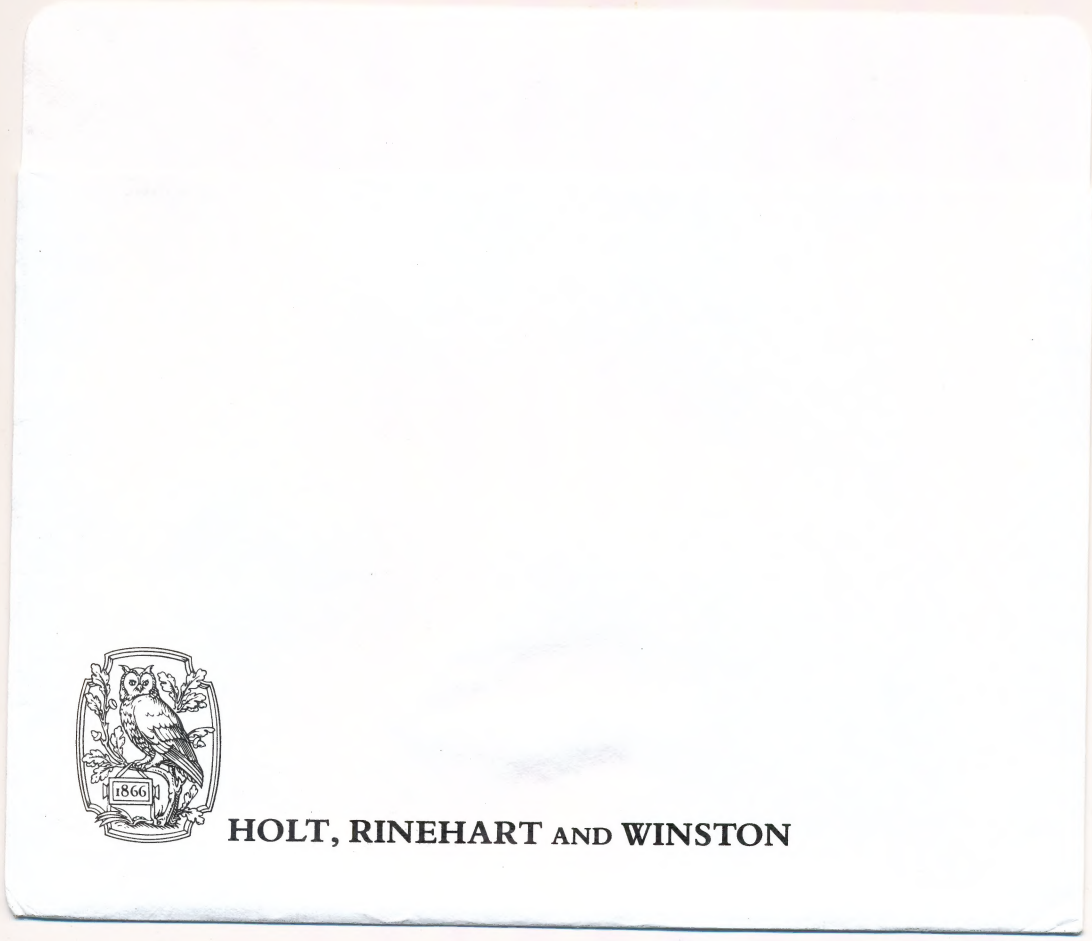
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Genetics, Disk 2

Side 2

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Video and Software Development
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# HOLT Courseware EVALUATION FORM

HOLT RINEHART WINSTON

Please register your name and school name/address. We appreciate your taking the time to complete this evaluation form. Feedback from professional educators is important so we may continue to provide materials that meet the needs of you and your students.

YOUR NAME _____ SCHOOL NAME _____

CITY _____ STATE _____ ZIP CODE _____

**PACKAGE TITLE:** _____ **GRADE LEVEL:** _____

**HARDWARE:**

**Apple:** ☐ IIe ☐ IIc ☐ GS **IBM:** ☐ PC___K ☐ PC JR. **Monitor:** ☐ Color ☐ Monochrome

**Other:** _____ ☐ Single Drive ☐ Dual Drive

## PART A: INSTRUCTIONAL PURPOSES

For which of the following instructional purpose(s) can this package be used? (Mark all that apply.)

1 ☐ Drill & Practice
2 ☐ Tutorial
3 ☐ Remediation
4 ☐ Enrichment
5 ☐ Problem Solving
6 ☐ Simulation
7 ☐ Educational Games
8 ☐ Testing
9 ☐ Instructional Management

## PART B: CONTENT CHARACTERISTICS

**Key:** SA = Strongly Agree A = Agree SD = Strongly Disagree D = Disagree NA = Not Applicable

| SA | A | SD | D | NA | |
|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | The content is factually accurate. |
| ☐ | ☐ | ☐ | ☐ | ☐ | The package's content is free of bias and stereotypes. |
| ☐ | ☐ | ☐ | ☐ | ☐ | The content is appropriate for intended level. |

## PART C: INSTRUCTIONAL CHARACTERISTICS

| SA | A | SD | D | NA | |
|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | The purpose of the courseware is well-defined. |
| ☐ | ☐ | ☐ | ☐ | ☐ | The courseware achieves its defined purpose. |
| ☐ | ☐ | ☐ | ☐ | ☐ | Presentation of content is clear and logical. |
| ☐ | ☐ | ☐ | ☐ | ☐ | The package is appropriate for my students' interest and maturity level. |
| ☐ | ☐ | ☐ | ☐ | ☐ | The level of difficulty is appropriate for intended users. |
| ☐ | ☐ | ☐ | ☐ | ☐ | Graphics/color/sound enhance the instructional presentation. |
| ☐ | ☐ | ☐ | ☐ | ☐ | The package holds the interest of students. |
| ☐ | ☐ | ☐ | ☐ | ☐ | Feedback on student response is effective and appropriate. |
| ☐ | ☐ | ☐ | ☐ | ☐ | The student instructions are clear. |

## PART D: TECHNICAL CHARACTERISTICS

| SA | A | SD | D | NA | |
|---|---|---|---|---|---|
| ☐ | ☐ | ☐ | ☐ | ☐ | The screen display is clear and easy to read. |
| ☐ | ☐ | ☐ | ☐ | ☐ | The package is free of technical problems. |
| ☐ | ☐ | ☐ | ☐ | ☐ | The user-support materials (i.e., documentations) are clear. |
| ☐ | ☐ | ☐ | ☐ | ☐ | The user-support materials are comprehensive. |
| ☐ | ☐ | ☐ | ☐ | ☐ | Intended users can easily and independently operate the program. |
| ☐ | ☐ | ☐ | ☐ | ☐ | The package requires minimum teacher monitoring. |

## PART E: QUALITY OF PACKAGE

Write a number 1 (low) to 5 (high) that represents your opinion of the quality of the package.

_____ Content Characteristics _____ Instructional Characteristics

_____ Technical/Presentation Characteristics

### OVERALL ASSESSMENT (Mark your response.)

1. ☐ Very satisfied
2. ☐ Satisfied
3. ☐ Dissatisfied
4. ☐ Very Dissatisfied
5. ☐ Neither Satisfied nor Dissatisfied

### OVERALL RECOMMENDATION (Mark your response.)

1. ☐ I would recommend this package to a colleague.
2. ☐ I would recommend this package to a colleague only if certain changes were made (please note changes below).
3. ☐ I would definitely not recommend this package to a colleague.

## SUMMARY

Please use the space below to let us know what you perceive as the major educational strengths and weaknesses of this package (consider content, instructional, and technical characteristics).

Please fold your completed evaluation in half so that the return address is on the outer portion of the self-mailer, and tape your evaluation closed. Thank you.